

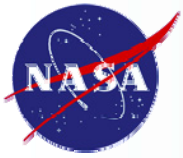


Hypersonic Vehicle Propulsion System Simplified Model Development

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This document addresses the modeling task plan for the hypersonic GN&C GRC team members. The overall propulsion system modeling task plan is a multi-step process and the task plan identified in this document addresses the first steps (short term modeling goals). The procedures and tools produced from this effort will be useful for creating simplified dynamic models applicable to a hypersonic vehicle propulsion system. The document continues with the GRC short term modeling goal. Next, a general description of the desired simplified model is presented along with simulations that are available to varying degrees. The simulations may be available in electronic form (FORTRAN, CFD, MatLab,...) or in paper form in published documents. Finally, roadmaps outlining possible avenues towards realizing simplified model are presented.



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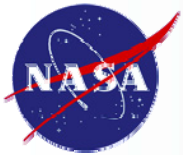
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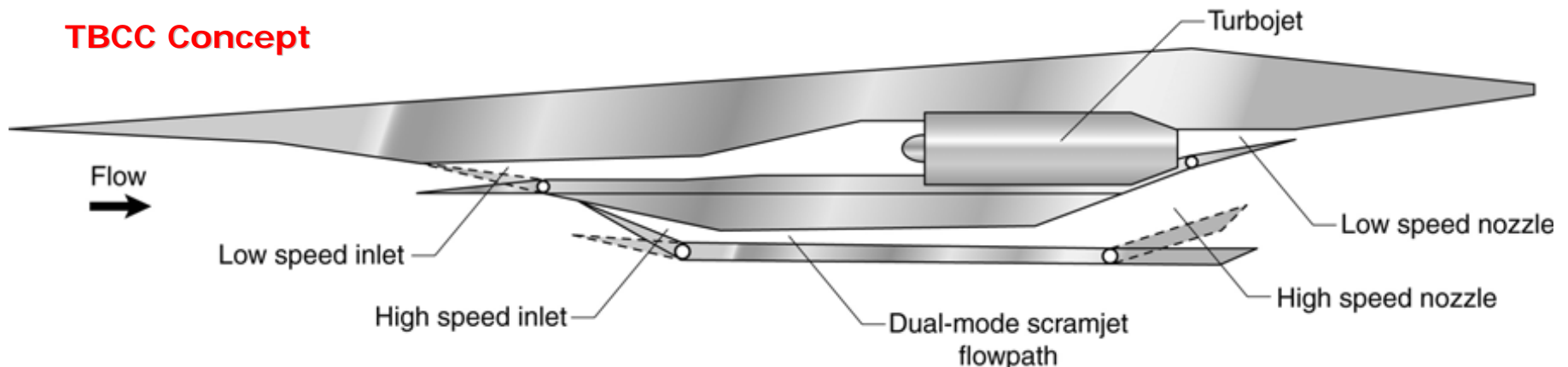
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Hypersonic Project GNC

- Interested in Controlling the Hypersonic Vehicle Propulsion system.
- Gain insights in Propulsion-Control and Flight-Control coupling issues.
- Four Basic Elements Necessary to Design Controllers:
 - Models,
 - Objectives,
 - Admissible controllers, and
 - Controller performance Metrics.
- Propulsion system primary Components:
 - Fore body compression surface,
 - Inlet,
 - Isolator
 - Combustor, and
 - Expansion Nozzle.

TBCC Concept



Albertson, C.W., Emami, S., and Trexler, C.A., "Mach 4 Test Results of a Dual-Flowpath, Turbine Based Combined Cycle Inlet," AIAA 2006-8138.

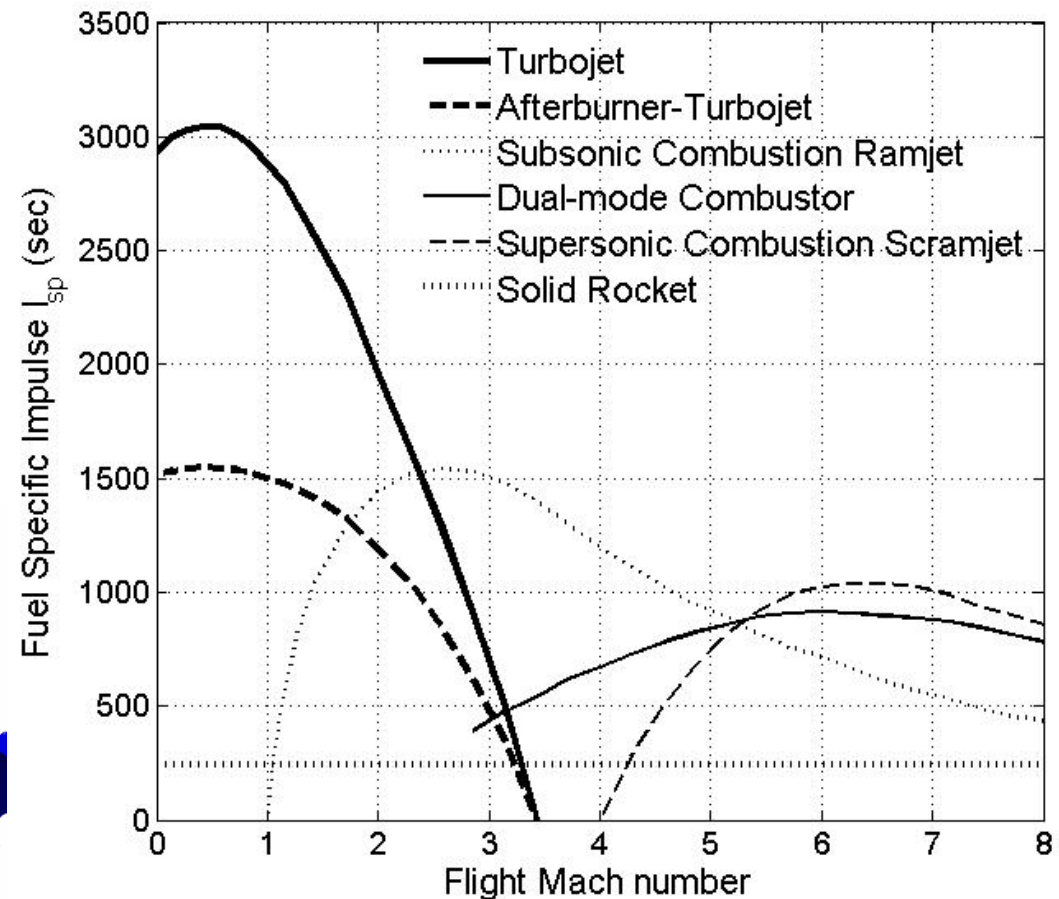
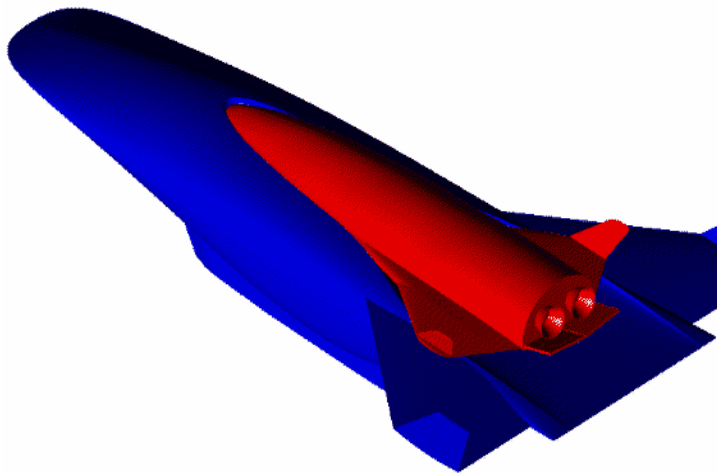


Hypersonic Propulsion System

The Vision vehicle:

- Turbojet or afterburning turbojet
- Dual-Mode Combustor

Transition from one flow path to another is a critical and enabling procedure for the hypersonic vehicle.

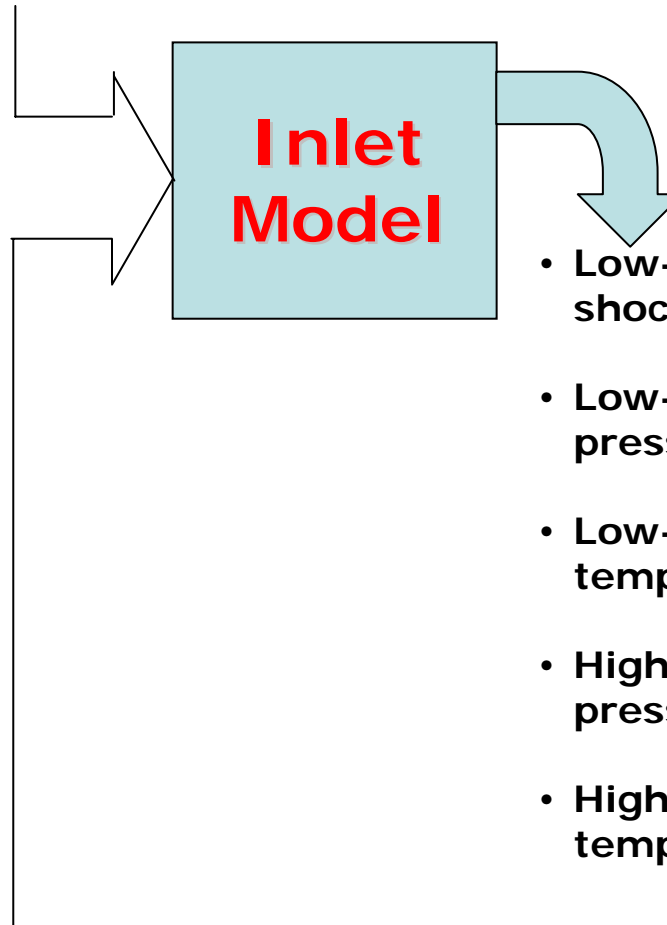


Billig, F.S., "Tactical Missile Propulsion," Progress in Astronautics and Aeronautics Volume 170, "Tactical Missile Design Concepts," AIAA, ISBN 1-56347-188-3, 1996.



Simplified Inlet Model Structure

- Free-stream conditions.
- Low-speed path cowl position.
- Low-speed path ramp position.
- Low-speed path bleed flow.
- Low-speed path back flow rate.
- High-speed path cowl position.
- High-speed path back flow rate.



- Low-speed path normal shock position.
- Low-speed path axial pressure distribution.
- Low-speed path axial temperature distribution.
- High-speed path axial pressure distribution.
- High-speed path axial temperature distribution.



Analytical Resources

Electronic Resources

- LAPIN
- SRGULL

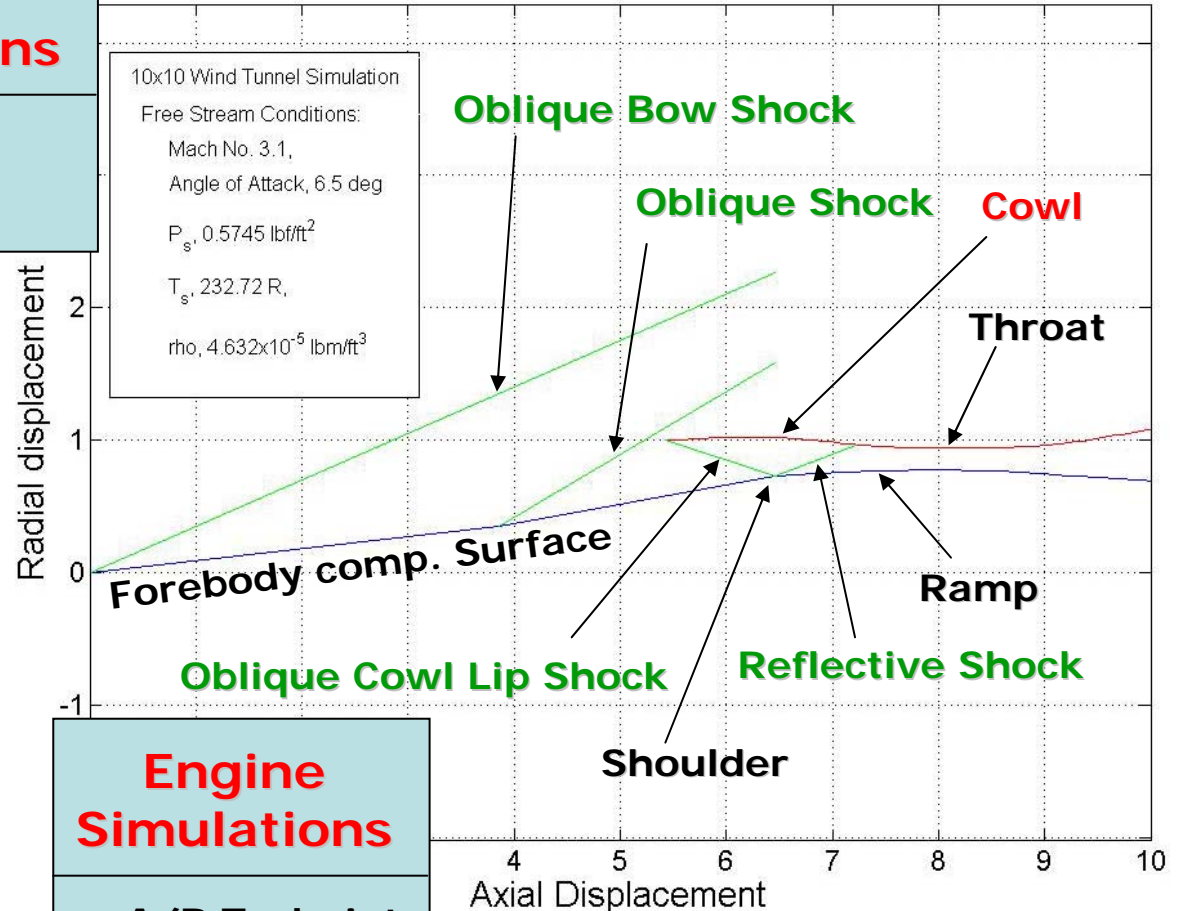
Vehicle Simulations

- GHAME
- AFRL

Supersonic Inlet Simulations

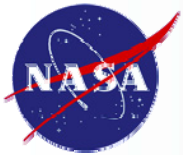
- NACA reports,
- Compressible Flow Toolbox,
- Sorensen,
- Anderson,
- Willoh, Cole, Melcher, and Johnson,
- Amin,
- Pratt and Heiser,
- Kumar,
- Pinckney, and
- Chicatelli.

L-IMX Low-Speed Flow-Path External Shock Structure

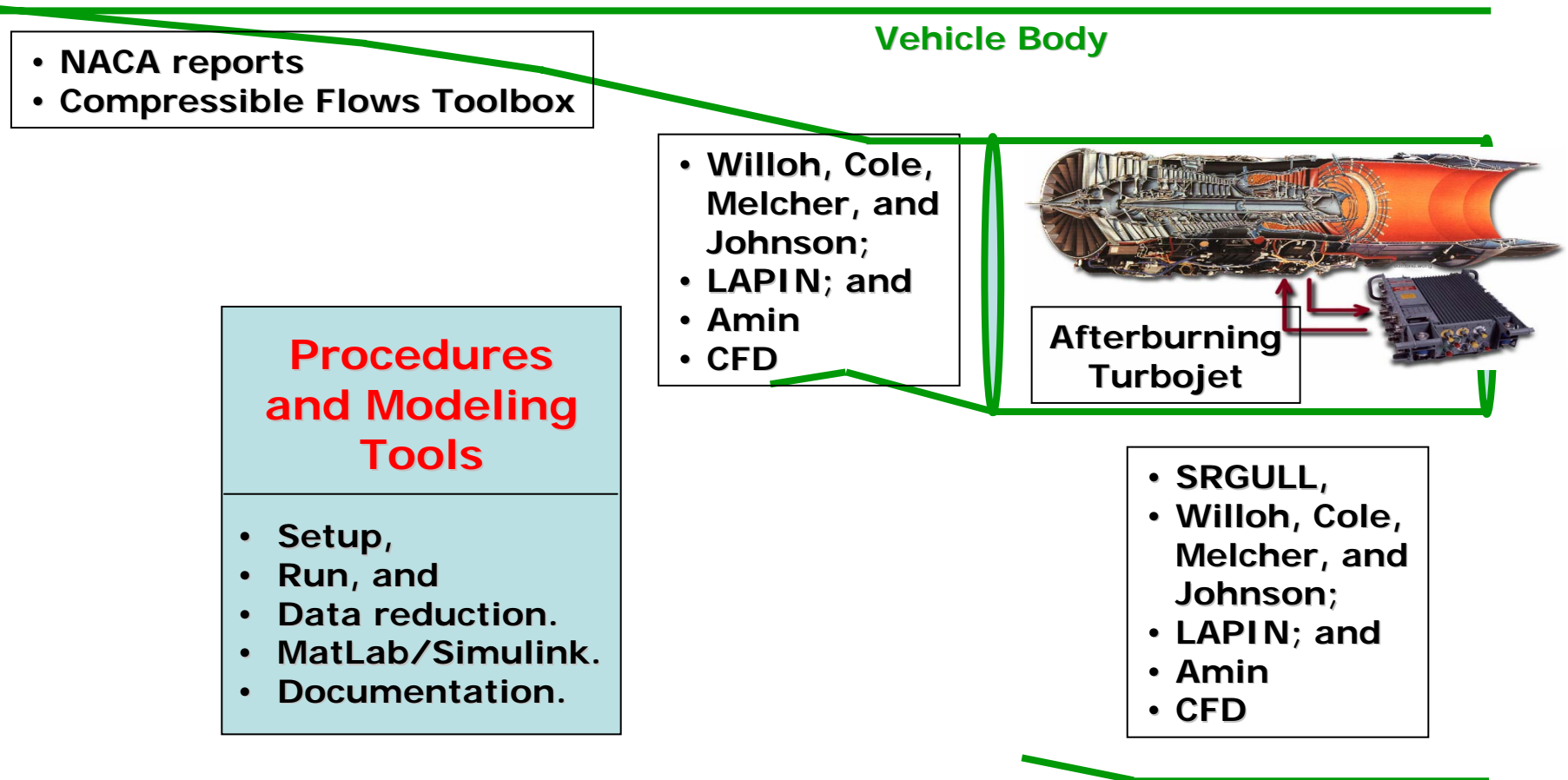


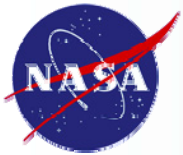
Engine Simulations

- A/B Turbojet
- SRGULL

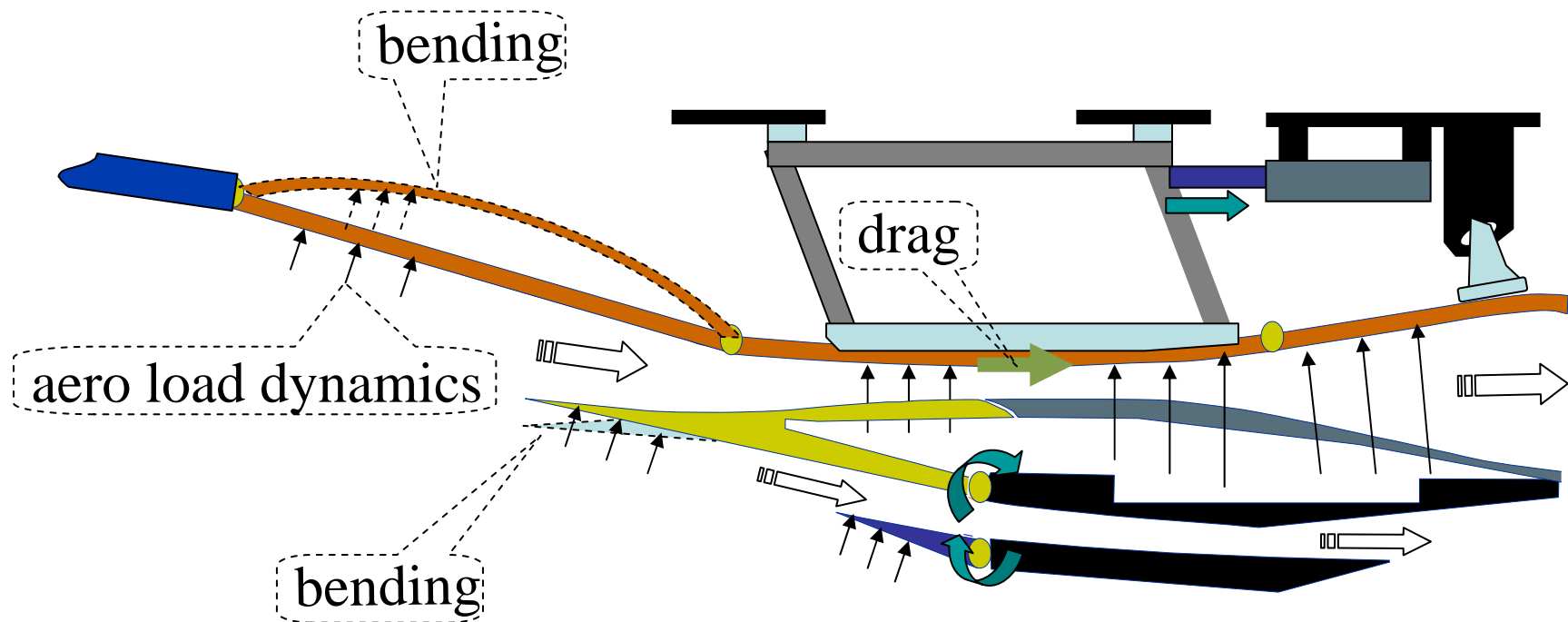


Propulsion Modeling Roadmap





Aero-Servo-Elasticity Aspects

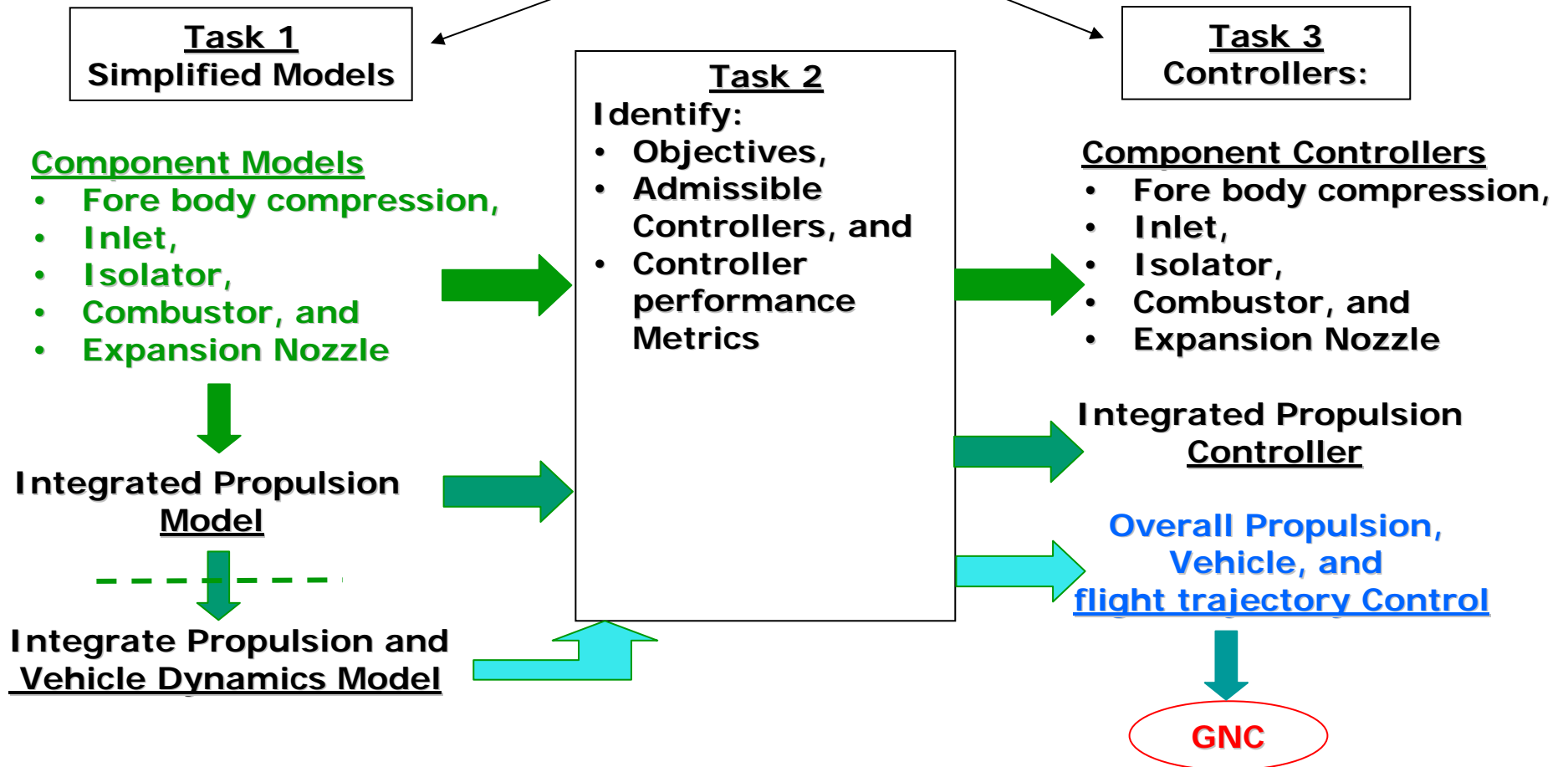


Large Scale Mode Transition Inlet (L-IMX)



Hypersonic Project GNC Overview

Develop Tools and Procedures





Long Term Schedule (L-IMX)

1. L-IMX: Performance, operability, and mode transition testing.
 2. C-IMX: Control research and development.
 3. CCET: Integrated inlet system with engines.
-
1. High speed flow path simulations.
 2. Low-speed flow path simulations.
 3. Simplified L-IMX computational models.
 4. Simplified engine simulations.
 5. L-IMX Schedule and Controller designed.
 6. Inlet controller coupled with engine control.

